Validity Evidence for Two Brief Fruit and Vegetable Assessment Instruments Among 3rd Grade Students

A Thesis
SUBMITTED TO THE FACULTY OF
UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE

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July 2014

Acknowledgements

I would like to express my gratitude to my two advisors, Marla Reicks and Abby Gold, who gave me this opportunity to learn accompanied with constant guidance and positive encouragements. I would also like to extend my appreciation to Ali Hurtado, Kit Alviz, and Dylan Galos. They helped me by sharing resources and also giving me support whenever needed. Thanks to Lori Roth-Yousey and Kim Vuong, my two dedicated data collectors who helped complete all of the interviews in the study. Finally, I am extremely grateful of the students, parents, teachers, and staff of the school and the community center for allowing me to enter their facility and interview the children. I especially want to thank the students for their kindness and generosity for their willingness to talk to me.

Dedication

This thesis is dedicated to my close friends and families who have supported me through the grueling writing process.

Abstract

Brief dietary instruments with validity evidence are used to assess fruit and vegetable intake in adults because they are inexpensive and easy to administer compared to 24-hour dietary recalls or assessment with biomarkers. However, use of these tools with young children without prior examination of evidence for validity may compromise data accuracy. The purpose of this study was to evaluate the validity evidence for two brief methods/instruments to estimate fruit and vegetable intake among 3rd-grade children. One instrument used a single retrospective question each about usual fruit and usual vegetable intake illustrated with measuring cup pictures (FVQ) to estimate amounts. The other instrument was a food record based on A Day in the Life questionnaire (DILQ) that measures intake frequency. Third grade students from one school and one community center (n = 107) in the metropolitan Minneapolis/St. Paul area participated in the study in 2012 and 2013. Three 24-hour dietary recalls were conducted using Nutrition Data System for Research (NDSR) to validate the FVQ and one recall to validate the DILQ. The first recall was conducted on the same day the two questionnaires were completed and the other two recalls were conducted within a 2-3 week period of time. Recalls were collected for 2 weekdays and 1 weekend day. An algorithm derived from National Health and Nutrition Examination Survey (NHANES) data was used to convert frequencies measured by the DILQ into amounts. Bland-Altman and deattenuated Pearson correlation coefficients were used to compare agreement between intakes assessed with the 24-hour dietary recalls and the FVQ and DILQ. Deattenuated Pearson correlations were moderate between 24-hour dietary recall and DILQ results (0.38 for fruit and 0.38 for vegetables).

Deattenuated Pearson correlations between FVQ and 24-hour dietary recalls results were strong (0.54 for fruit and 0.58 for vegetables) based on the low reliability of multiple 24-hour dietary recall data. Therefore, the strength of these correlations is misleading. Participants overestimated fruit intake using both tools and vegetable intake using the FVQ. Participants underestimated vegetable intake by 0.37 cup using the DILQ. The limit of agreement for all comparisons was high. Therefore, evidence of validity for the FVQ and DILQ was lacking for evaluation of fruit and vegetable consumption in the current sample of 3rd grade students. Other assessment methods/instruments should be considered for use with younger children.

Table of Contents

List of Tables

List of Figures

Introduction

The prevalence of overweight and obesity was 34% among U.S. children (6-11 years) according to National Health and Nutrition Examination Survey (NHANES) data (2011-2012).[1] Children in this age group were also found to consume less than recommended amounts of fruit and vegetables.[2] Intervention efforts target school children to encourage healthy eating behaviors and increased fruit and vegetable consumption to address obesity prevention and health maintenance. Choosing dietary assessment tools is therefore essential to examine the effectiveness of interventions to improve intakes of school children.

Dietary assessment tools are instruments that evaluate dietary intake and patterns of individuals or groups. Assessment tools are important in assessing the effectiveness of nutrition intervention programs that encourage healthful dietary behavior to decrease obesity risk.[3] In order to evaluate intervention effectiveness, assessment tools should show evidence of validity and reliability, and be sensitive enough to detect changes. In addition, given limited resources, researchers must find inexpensive and efficient dietary assessment tools for evaluating outcomes.[4] Therefore, a need exists to develop valid, inexpensive, and brief dietary measurements for use with children.

Many challenges exist in developing or identifying measurement tools that show evidence of validity with children. Information about the diet of preschoolers can be collected from surrogates such as parents or caregivers, however, surrogates may not have knowledge of dietary intake of school children because children may eat several meals away from home. Furthermore, children may have limited ability to recall what they have eaten, estimate portion sizes, and identify names of foods.[5] Children between 7 to 12 years of age, may be motivated to report their intake because they are curious about the data collection process.[5]

Several diet assessment tools have been used in pediatric populations. Food records, food frequency questionnaires (FFQs), brief screeners, 24-hour dietary recalls, and a group-administered 1-day diet record have been used to assess dietary intake and eating behavior among school children. The evidence of validity for these instruments varies and each has its own advantages and disadvantages to consider when deciding which instrument to use in research studies. More research is needed to identify instruments with strong validity evidence that can be completed by school children.

1. Literature Review

1.a Fruit and vegetable consumption among elementary school children

Most U.S. school-aged children (6-11 years) are not eating the recommended number of servings of fruits and vegetables.[2] The 2010 Dietary Guidelines for Americans recommends that children 8 to 9 years of age consume 1.5 to 2 cups of fruits and 1.5 to 2.5 cups of vegetables daily for health benefits.[6] However, on average, children aged 6 to 11 years in the U.S. eat 1 cup of fruit and 1 cup of vegetables based on NHANES data from 1999 to 2001.[2] NHANES data collected in 2001-2004 based on two 24-hour dietary recalls showed that on average, children from 4-13 years ate only 1 to 1.1 cups of fruit and 1 to 1.3 cups of vegetables per day.[7] Although children were not eating recommended amounts of fruit and vegetables, there was a trend for increased intake of fruit and decreased intake of fried potatoes, fruit juice, starchy vegetables and starchy vegetable dishes among youth (2-18 years) based on the Continuing Survey of Food Intakes by Individuals (CFSII) 1989-1991, 1994-1996, and 1998 and NHANES 2003-2010.[8] Intake of vegetables remained stable throughout the decade.

Fruit and vegetable consumption may be dependent on family income. When fruit and vegetable intake from NHANES data (2001-2004) among children was stratified by income groups, more children in the highest poverty income ratio group (29.1% of children) met the recommendation for fruit intake than those in the middle poverty income ratio group (24.8%). However, the group with the fewest number of children meeting the recommendation for vegetable intake was the highest poverty income ratio group (5%).[9] Interestingly, children in the lowest income group were more likely to consume greater than the recommended amount of dried beans and peas.[9] Ethnicity can also influence fruit and vegetable intake. Mexican American children were more likely to eat the recommended amount of fruits and vegetables, especially whole fruits, dried beans and peas, and other vegetables compared with non-Hispanic children.[9]

Other studies have found children in low-income households consume less than recommended amounts of fruits and vegetables. Robinson-O'Brien and colleagues assessed fruit and vegetable intake of students (9-12 years) consuming school meals in schools serving low-income populations in the Minneapolis/St. Paul region. Students on average ate 2.1 daily servings (1.05 cups) of fruit and 1.5 daily servings (0.75 cup) of vegetables, excluding fried potatoes.[10] Another study found that Hispanic children (mean age = 10.7 years) from North Carolina from food insecure households ate 1 daily serving (0.50 cup) of fruit and 1.61-1.70 daily servings of vegetables (0.81-0.85 cup).[11] These studies indicate that low income or food insecure children are not meeting recommendations for fruit and vegetable intake and could benefit from efforts to encourage greater intake.

1.b Health benefits from fruit and vegetable consumption

The benefits of consuming fruits and vegetables for adults have been well-documented.[12] Consuming the recommended amounts of these two food groups has been beneficial in lowering risk of chronic diseases in adults including certain cancers,[13] type 2 diabetes,[14] heart disease and stroke.[15] The incidence of death from stroke and cancer in adulthood was lower when participants had higher vegetable (excluding potatoes) and fruit intake during childhood.[16,17] Higher intake of French fries in childhood was associated with a higher incidence of breast cancer among adult women.[18] Eating more fruit and vegetables is beneficial for children when they are young. Among healthy African American children, eating more deep green and yellow vegetables was positively associated with higher bone mass[19] and eating more fruit was associated with greater insulin sensitivity.[20] Fruit and vegetable intakes were also negatively associated with systolic blood pressure,[21,22] prevalence of metabolic syndrome in children,[23,24] and decreased markers of inflammation in adolescents.[25]

Eating fruits and vegetables may replace intake of less healthy foods such as high fat and high sugar foods.[26] High intakes of fruits and vegetables were associated with lower dietary energy density among Swedish children and adolescents according to Patterson and colleagues.[27] In addition, consuming lower energy density meals was negatively associated with weight status of children (2-8 years).[28] Therefore, increasing fruit and vegetable intakes may result in lower dietary energy density and decreased incidence of childhood obesity.[28] However, several studies did not show conclusive results with respect to the relationship between body weight and fruit and vegetable consumption among children.[29–31]

1.c Measures of fruit and vegetable consumption by children

Because children in the U.S. are generally not meeting recommendations for fruit and vegetable intakes, many interventions have been developed to improve children's intake. Within these interventions, tools that evaluate children's consumption of fruit and vegetables are needed to determine intervention effectiveness.

Fruit and vegetable dietary assessment tools are designed to estimate the type and amount of fruits and vegetables an individual consumes over a period of time. The tools largely depend on participants' memories.[3] Children are often not able to recall past intake as accurately as adults[5,32] and are unable to estimate the amount of food they have eaten without assistance.[33] Difficulty with recall may be related to several factors. First, 7-11 year-old children are still in the concrete-operational cognitive stage of development and are less able to think in abstract terms.[34] Recalling precise food amounts requires abstract thinking in order to look at food models or pictures with different dimensions and then determine past intake based on the models.[5,34]

Food intake recall is part of episodic memory. Episodic memory pertains to an event that happens once at a specific location.[35] Events in episodic memory are less memorable than big events such as delivering a speech or a first date; therefore, it is unlikely that details of food intake can be accurately recalled by children. Lastly, school children eat a greater variety of foods compared with preschool children.[5] All of these factors contribute to the difficulty in recalling food intake by children. When estimating dietary intake, the period of time between actual intake and recall should be shorter for children compared with adults.[36] Children may be asked to recall what they ate in the past day or week or month, whereas adults may be asked to recall intake over the past several months to a year.[32] Given these limitations, researchers need to better understand children's cognitive processes when recalling dietary intake.

Baranowski and Domel described the cognitive processes whereby children (9-10 years) reported past food intake.[37] These authors suggested that children need to be aware of the type of food they were eating before remembering what was consumed, and that inattentiveness when eating could cause underreporting. Perception, interpretation, or knowledge also might influence diet recall as children could misidentify foods eaten with something else. These authors also suggested that consumed foods need to be correctly organized into long term memory because incorrect organization could result in recall errors. When dealing with unfamiliar foods, children could erroneously name the foods or only remember the ingredients. The inability to organize or pay attention might cause less retention of foods consumed and affect retrieval of information. Lastly, these authors suggested that children likely respond in a socially-desirable manner and report greater intake of healthy foods (fruit and vegetables) and lower intake of less healthy foods (candy and desserts).[37]

The lack of cognitive ability in children to recall food intake has raised questions of instrument validity when assessing intake of children. This has led to many studies of the validity (commonly referred to as accuracy) of different dietary assessment tools. Comparing results from food frequency questionnaires or brief screener tools to results from 24-hour dietary recalls, which are more time and labor-intensive, may lead to more accurate results and ultimately lead to the creation of valid and reliable instruments that measure food intake in children.

Parental proxy report may be one method to manage inaccurate dietary intake reporting by children. However, students have highly variable diets[36] and many consume a substantial portion of their daily intake away from home (e.g., school breakfast and school lunch). Thus, parents may not be able to accurately report their children's intake.[38] This thesis will mainly focus on dietary instruments that can be completed by children without parental assistance.

i. Description of common tools

Food frequency questionnaires, brief screeners, and dietary recalls are common tools used when measuring fruit and vegetable consumption among children. Each tool has its own distinct advantages and disadvantages based on the type of study, dietary assessment outcomes, accuracy, respondent and investigator burden and extent of validation efforts.

Food frequency questionnaires (FFQs)

FFQs assess the frequency of eating specific foods in a specified time frame. The number of questions or food items on FFQs varies depending on the aims of the study. To shorten the surveys, questions are often grouped by type depending on participant demographics and research aims.[39] Brief screener FFQs that focus on certain food groups such as fruits and vegetables can contain as few as 7 items.[40] When the research aims involve assessment of calorie and nutrient intakes, the number of food items can be up to 137 items.[41] When FFQs are developed to match participants' ethnicities or country of birth, researchers will include specific food items that are most appropriate for their target populations or sub-populations to accurately capture participants' food intake.[42,43]

Because some FFQs collect information about frequency of consumption and not serving sizes, evaluating validity evidence for FFQs may involve converting frequencies into servings. An algorithm that converts frequency to servings is available from the National Cancer Institute (NCI)[44] for the U.S. population. Briefly, the algorithm is used to compute portion sizes using data from the Eating at America's Table Study (EATS) in NHANES 2003-2006 participants regarding amounts typically consumed per eating occasion.[44] Researchers use different algorithms for food group types, age groups, and gender type. Another method of computing portion sizes is available for European populations called the Multiple Source Method (MSM).[45] This method provides typical food intakes of individuals based on their short term food intake. The probability of consuming each food and the amount consumed is considered in the modeling process.[45] The MSM is similar to the NCI method except that the MSM is able to assign zero intakes to individuals when they do not consume anything.[45]

The semi-quantitative FFQ is a subtype of FFQ. Instead of asking about frequency only, a semi-quantitative FFQ asks for frequency of intake based on standardized portion sizes. Researchers may provide a description of what a standard portion size is (e.g., a serving size is 1 medium piece of whole fruit)[46] in the questionnaire. This eliminates the need to convert frequency of intake into servings or amounts. Some semi-quantitative FFQs are further improved by asking children to fill in the frequency of consumption of food items, and requesting that parents or caregivers fill in the usual portion sizes that children eat and drink.[47]

Cade and colleagues provided evidence of validity for a FFQ in the form of a 24-hour tick list which was completed by children (3-7 years), a parent classroom assistant, a dinner supervisor and parents. Foods consumed by individual children that day were ticked or marked. The tick-list consisted of 27 to 92 foods, depending on the survey respondents. After the meal, children, parents or staff in school ticked the foods that children ate during the meal on that day. No information about the amount of foods was requested in the surveys. Frequencies were converted using the National Diet and Nutrition Survey (NDNS) in the United Kingdom. Spearman correlation coefficients for fruits, vegetables, and total fruits and vegetables between the tick list and weighed food diaries completed by researchers and parents were 0.52, 0.56, and 0.40[47] which are considered moderate to strong correlations.[48]

A FFQ used to measure fruit and vegetable intake among children in another study was a 137-item semi-quantitative FFQ. The FFQ was completed by parents with children (5-12 years). Results from the FFQ were compared with biomarkers such as plasma carotenoids and lutein. Correlations between parental reports and plasma beta-carotene were 0.54 for fruits and 0.54 for vegetables after adjusting for BMI of children.[41] However, when a different FFQ was filled out by 5th grade students in Puerto Rico, the correlations for nutrients assessed by the FFQ and food diaries (completed by students and parents) were lower than 0.2 for all nutrients. [49] Furthermore, Hmong children (9-13 years) overestimated fruit and vegetable intake using the Block kid's FFQ (77 food items) compared with two 24-hour dietary recalls.[50] These studies suggest that FFQ reports filled out by only parents or both parents and children together may yield more accurate responses than when children complete the FFQ alone. Parent involvement can burden researchers who have limited time or resources to support this method. Using brief screeners to collect children's consumption information may alleviate the complexity involved with parental assistance.

Researchers need to consider strengths and weaknesses of FFQs when deciding which instrument to use. FFQs can capture long-term usual intake of participants as they regularly ask for information about intakes over a period of time.[51] Administration of FFQs is easy and inexpensive so they can be used in large population studies. FFQs are highly customizable to fit specific ethnic groups or individuals in different regions. Weaknesses include the fact that children may not be capable of estimating frequency of consumption of foods over a certain amount of time and the dependence on long term memory may impede the accuracy of recalling typical consumption.[38] Also, studies found children overestimate intake using FFQs.[32,52,53] FFQs are a better measurement for frequently consumed food compared to measuring less commonly consumed food.[52] This could be problematic for children whose food intakes are highly variable.[36] The major weakness of FFQs is that they are not as accurate as other dietary measurement methods such as 24 hour dietary recalls or food records, as they do not collect food details, in real-time from participants.[36]

Brief screeners

While data from FFQs can represent a total diet assessment based on frequency and information about portion sizes, brief screeners can be structured to focus on only certain aspects of diet with or without portion size information.[36,54] Brief screeners may also serve as a tool to create interest among participants in healthy eating promotions.[36] In addition, results of screeners with validity evidence can serve to inform those who make school nutrition policies.[55] The type of questions in brief screeners are similar to

FFQs which request information about the frequency of food intake but are usually limited to specific food groups or foods of interest. Brief screeners are often used in the assessment of fruit, vegetable and fat consumption.[36] Screeners developed to assess intake of specific micronutrients such as calcium[56–58] among children aged 9 and above were found to support validity evidence when compared to multiple 24 hour dietary recalls. Brief screeners often do not provide information on the whole diet, therefore these tools cannot accurately measure energy or all macronutrients and micronutrients.

Studies have shown mixed results when evaluating validity evidence for brief screeners among children using observational methods,[40] food records[47,59,60] or 24-hour dietary recalls.[61,62] Brief screeners are thought to be unsuitable for measuring children's intakes for several reasons. Children may be too young to rationally estimate and calculate frequency of intake arithmetically.[60,63] However, some researchers have proposed that brief screeners may be more useful among children if completed with parental assistance[59] and included portion sizes as descriptions to help children visualize intake.[61] Slater et al.[64] reported a higher correlation between screeners estimating fruit and vegetable intake and carotenoid biomarkers than between fruit and vegetable intake and 24-hour dietary recalls. This unexpected finding could be based on differences in populations, sample sizes, or structure of the questions.[64]

The Food Behavior Checklist (FBC) developed by the University of California Cooperative Extension, University of California Davis, is a type of brief screener used with low-income adult women.[65] The FBC contains 22 questions to measure participants' behavior before and after nutrition education classes to assess change that could be attributed to the nutrition education. Studies of the FBC have provided evidence of validity in terms of accuracy of responses[41–43] and readability[69,70] among women in different ethnic groups. Branscum and colleagues examined the reliability and construct validity (how well the questions are measuring the construct of interest)[71] of the FBC modified for children (FBC-MC) with 8 to 9-year-old low-income children. Questions related to food insecurity were excluded from this checklist. Confirmatory factor analysis showed evidence of validity for the FBC-MC but not reliability. Therefore, researchers suggested that some survey questions be modified and tested with a larger group of children.[72]

A modified version of the FBC used to determine fruit and vegetable intake among children is the Fruit and Vegetable Questionnaire (FVQ). Two single retrospective questions from the FBC about usual fruit and usual vegetable intake illustrated with measuring cup pictures (FVQ) are included.[65] The wording of the question in the FBC ("How much do you eat each day?") differs slightly from the question in the FVQ (How many cups of vegetables/fruits do you eat on most days?). The measuring cup pictures in the FVQ reflect the MyPyramid guidelines for intake of fruits and vegetables. The pictures of these fruits and vegetables are included to help children visualize the amount they have eaten in terms of a variety of foods. Even though juices are not included in the pictures, the instruction guide encourages researchers to emphasize that 100% juices with no sugar-added beverages can be counted toward their usual intakes.

Brief screeners are useful and inexpensive, qualities which are attractive for many practitioners or researchers. Researchers need to be cautious when using brief screeners as a sole means of assessing dietary intakes, especially among children, as studies have shown mixed results regarding evidence of validity.

Dietary recalls

Twenty-four-hour dietary recalls are conducted in an interview format to obtain information from individuals about intake for one day. Trained interviewers ask participants about what the individual ate and drank during the previous day with appropriate probing methods. Interviewers are typically taught to use a multiple-pass method[73] when conducting 24-hour dietary recalls. The first pass is used to obtain a quick list of foods and beverages from participants. The quick list is then reviewed with participants. Probes help participants with items they may have forgotten. In the third pass, interviewers ask about details of each food or beverage consumed including amount, brand name and cooking methods. However, children may be less likely to know brand names or cooking methods compared to adults. Finally, interviewers review to confirm details reported by participants.[74]

Two software packages are available to enter and analyze interview data. First, USDA has developed its own Dietary Intake Data System which consists of the Automated Multiple Pass Method (AMPM), an interview-software program used to collect food intake, the Post-Interview Processing System (PIPS), a system that assigns specific codes to different foods, and Survey Net, another system that assigns codes and analyzes data.[73] AMPM has been assessed for validity evidence among 20 premenopausal women. Results were then compared with 14-day food records and doubly-labeled water (an assessment method to measure total energy expenditure). Energy and nutrient intakes were not significantly different between these methods.[75] Second, the Nutrition Coordinating Center (NCC) at the University of Minnesota has developed another interview-software program that uses its own food database and data analysis program called Nutrition Data System for Research (NDSR).[76] Thus, researchers can choose either one of the software programs based on familiarity with the program.

Lytle et al.[77] provided validity evidence for 24-hour dietary recalls collected with NDSR software from children as young as 8 years. Intakes from dietary recalls were compared with observational methods and showed a moderate to strong correlation of 0.41 to 0.79 for nutrients.[48] The observation was conducted by researchers when children were in school and by parents when children were at home. Children overestimated or underestimated portion sizes for all food groups.[77] In a study by Crawford and colleagues, 24-hour dietary recalls yielded agreement of 0.46 to 0.79 in terms of nutrients when compared with observational methods with children (9-10 years).[78] Lytle and colleagues conducted a study with 4th grade students and observed moderate to strong correlations of 0.65, 0.42 and 0.52 between observed intake and intake based on 24-hour dietary recalls for fruit, vegetables, and total fruit and vegetables, respectively.[79] Among all students, some were assigned to keep food records the day before the recall which resulted in higher agreement between recalls and observation compared with students who did not keep food records.[79] To further improve the 24-hour dietary recall protocol, Baxter et al. included physical activity questions in the recall.[73] However, no significant differences were noted in accuracy[80] indicating that the current interview protocol is optimal to collect recalls. In summary, 24-hour dietary recalls collected from children by trained interviewers are one of the better methods to obtain dietary intake information.

Although 24-hour dietary recalls are more accurate than other methods to estimate intake, dietary recalls are very expensive as training and usage of specialized software can be costly. Training interviewers is critical when conducting recalls as adherence to an interview protocol can affect the quality of the interview.[81] When estimating usual intakes, multiple recalls are needed. Multiple recalls increase respondent burden. Recalls are usually restricted to small population studies by cost and time to execute.

Group-administered 1-day dietary recall

A group-administered 1-day dietary recall does not involve an interview to obtain diet information but instead uses questionnaires which can be distributed in group settings. One example of this dietary recall is the A Day in the Life Questionnaire (DILQ).[82] The DILQ contains 16 questions about diet and activities for the previous day. Children write down the name of foods and beverages they ate. They can also draw pictures of the foods they ate for breakfast, lunch, and dinner. Activity-based questions serve to help children remember the food and drinks they consumed based on simultaneous activities. Also, these questions camouflage the intention of collecting information about fruit and vegetable intake. Fruit and vegetable consumption is calculated from the DILQ by tallying the number of times fruit, vegetables, and 100% fruit juice is written by students. The sum of foods can be compared before and after an intervention to identify whether nutrition education is successful. In the study by Edmunds and colleagues, nutrition education emphasized consuming whole fruits and vegetables, therefore, these researchers excluded mixed dishes that contained fruit or vegetables in their calculations.[82]

Three studies have assessed validity evidence for the DILQ among school children. Edmunds and colleagues found an agreement of combined fruit and vegetable intake in two different elementary schools (0.68 and 0.74) between the DILQ and observation conducted by the research team at school lunch and breaks with students (7-9 years).[82] Wallen and colleagues found similar agreement (0.65 for fruit and 0.73 for vegetable) between the DILQ and plate waste during school lunch with students (9-11 years).[83] However, Moore and colleagues found lower agreement when evaluating validity evidence for the DILQ with 24-hour dietary recalls with students (9-11 years). Spearman's correlation coefficients between the two instruments were 0.39 and 0.41 for fruit and vegetables, respectively, for the whole day excluding breakfast.[84]

A unique advantage of the DILQ is that teachers or researchers can administer the survey without much training in group settings. Administration in group settings saves time. Students and teachers liked this survey.[82,83] Agreement for the DILQ, when validation was conducted for a greater number of eating occasions than lunch, was moderate. Information about portion sizes of fruits and vegetables consumed is not requested from children completing the survey. Therefore, this limitation needs to be considered when deciding to use the DILQ as the sole dietary assessment method.

ii Validation methods

Validity is based on how well an instrument can measure what it is intended to measure.[85] Two types of validity can be described, absolute and relative or convergent validity.[86] Absolute validity is based on comparing dietary information obtained from self-report to direct observation. Gibson argued that the absolute truth or accuracy of dietary changes before and after interventions is possible only through direct observation.[79] However, these methods are complex and expensive to implement limiting the ability of researchers to use such methods.[86]

Researchers are most likely to assess relative or convergent validity. Relative validity compares test tools with previous reference tools with strong validity evidence that measure similar constructs.[86,87] For example, the DILQ and 24-hour dietary recalls can measure fruit and vegetable consumption, therefore they are measuring similar constructs. Thus, researchers were able to use 24-hour dietary recalls as a comparison to give a sense of relative validity to the DILQ.[88] Willett suggested that although 24-hour dietary recalls are subject to measurement error and rely solely on the best memory of the individual, 24-hour dietary recalls are the most useful method when participants are have low literacy or low motivation.[89]

In addition to 24-hour dietary recalls, measurements from test tools can be compared with measurements based on food records. A study conducted among 11 year-old students in Belgium and Italy used 7-day food records to validate the Health Behavior in School-aged Children (HBSC) FFQ.[83] Children were taught by a dietitian to fill out food records for six eating occasions including breakfast, lunch, dinner, and snacks after each meal. The dietitian encouraged children to ask for assistance from parents when completing the FFQ at home. Food records were completed immediately after foods and beverages were consumed, so the individual did not rely on memory. However, researchers still found that students inadequately described foods or omitted some foods.[90] Others also argued that food records may heighten the awareness of participants, therefore their eating patterns will change, which may result in lower correlation when evaluating validity evidence for the test tools.[89]

Another reference method researchers use in validation studies is to compare biomarkers with results from test tools.[86] Biomarkers are objective measurements from saliva, blood, urine or tissues that reflect dietary intake of specific foods or food groups and are not affected by dietary intake measurement errors. For example, researchers have used biomarkers such as beta-carotene to estimate intake of fruit and vegetables. Burrows and colleagues compared plasma carotenoid levels to parental report of children's fruit and vegetable intake in an Australian Child and Adolescent Eating Survey FFQ.[33] Parents of overweight and obese children reported greater dietary intake of carotenoids in the FFQ than what was reflected in plasma carotenoid levels of children. Researchers suggested that overweight and obese children may store higher levels of carotenoids in adipose tissue than plasma compared with normal weight children.[41] Therefore carotenoids may not be the best biomarker of fruit and vegetable intake when comparing overweight or obese groups with normal weight children.

Some common statistical analysis methods to measure relative or convergent validity are Pearson correlation analysis (coefficient r) and Bland-Altman analysis. Both methods measure the agreement between two readings from different dietary assessment tools.[91,92] While r only measures the linear relationship of the two variables, Bland-

Altman analysis takes into account variation in differences between the variables.[91,92] The r value can range from -1 to 1, which indicates a negative or positive relationship depending on the positive or negative sign, or no relationship at all when $r = 0$.[86] Instruments are considered to have good agreement when r is close to 1. For Bland-Altman analysis, two instruments are considered to have good agreement when the mean of differences of readings is close to 0 and the limits of agreement are narrow.[92]

Measurement errors are based on having readings that are different from true values provided by respondents for various reasons.[93] Because these measurement errors typically decrease the r value, an algorithm was proposed to deattenuate r (to remove measurement errors) in order to determine the true value of r.[89]

$$r_t = r_o \sqrt{1 + \lambda_x / n_x}$$

r_t = true correlation; r_o = observed correlation; λ_x = ratio of within- and between-person variances for x (readings from dietary assessment tools); n_x = the number of replicates per person for the x variable.

Many factors influence the accuracy of dietary intake reporting including body mass index (BMI). According to a 2007 Australian Children's Survey, children (2-16 years) who had higher BMI were more likely to under report energy intake and children who had lower BMI were more likely to over report energy intake.[94] Similar results were found in a Swedish study in which energy intake was reported in diet history interviews by overweight and obese children (mean age = 10.5) and compared with the doubly-labeled water and SenseWear armband measures (measurement of total energy expenditure).[95]

In addition to BMI, researchers need to consider the sample selection and time frame when designing validation studies. First, researchers should select a representative sample of participants that suits the aim of the research.[86] Researchers should be mindful of the ethnicity of participants as language and cultural background may affect the accuracy of the tool based on reading level and cultural appropriateness. Second, both the reference tool and test tool should measure the same constructs over the same time span.[86] For instance, a test tool which measures 1-day dietary intake must be matched with reference tools such as a 24-hour dietary recall or a 1-day weighed food record. If the test tool is a FFQ which measures usual intake, then the reference tool should reflect measurements spanning a period of time such as 7-day food records or multiple 24-hour dietary recalls.[86]

Other extrinsic factors that affect validity evidence include design of tools and data management.[85] Survey questions may not encompass all the diet sources of participants. Therefore, tools may have weak evidence of validity because they do not include the variety of foods that are typically consumed. Also, not including an adequate number of frequency categories to choose from will result in lower precision and agreement with the reference tool.[85] Furthermore, data management also plays a vital role in validity studies. A systematic approach to control the quality of data will result in less error in data entry and fewer problems during data analysis.[85]

iii Measuring change in intake

Dietary assessment tools are often used to detect or measure changes in dietary intake by comparing intake measured before and after an intervention. The ability to measure changes in intakes is called sensitivity or responsiveness.[96] Responsiveness can be measured by using observed changes in intakes pre- and post-intervention divided by the standard deviation of changes.[97] Responsiveness is affected by treatment effects, validity evidence of instruments and susceptibility of instruments to bias.[97]

Researchers have previously examined dietary assessment tools for responsiveness. The DILQ has been tested for sensitivity among students (8-9 years).[82] The DILQ was distributed on Tuesday and Friday, where free fruits were given on Thursday but not Monday. Mean fruit consumption on Thursday (1.43 counts of fruit) was significantly higher than Monday (0.96 counts of fruit). Thus, the DILQ was shown to be sensitive to capture changes in intake.[82]

In another study, a fruit and vegetable instrument was examined for sensitivity by comparing intakes before and after an intervention between pre-coded 24-hour dietary recalls and a FFQ.[98] Students (6-10 years) were given choices to subscribe to a fruit and vegetable program where they would receive one piece of fruit or vegetable each school day. Five weeks after the intervention, significant changes in fruit intake (0.4 piece, $p = 0.019$) but not vegetable intake were detected among subscribers and nonsubscribers (0.3 piece, $p = 0.008$) based on a pre-coded food diary (a semi-quantitative 215-item food diary similar to a FFQ). However, no significant differences in fruit intake were observed among subscribers based on the FFQ (0.1 piece, $p = 0.104$).[98] The FFQ may not have been able to detect very small changes and therefore was not as sensitive compared with pre-coded 24-hour dietary recalls.

Moore and colleagues examined the sensitivity of a computerized 24-hour dietary recall questionnaire among students (9-11 years). Students' recalls were compared between schools that had "no food", "no restriction" and "fruit only" policies for bringing snacks to school for morning break. The computerized 24-hour dietary recalls were more sensitive for detecting differences in fruit intake among students in "fruit only" policy schools which had significantly higher fruit intake compared with "no food" policy schools. Conversely, students at schools with "no restriction" policies were reported to have significantly higher intake of sweets, chocolate, and biscuits compared with students at schools with "no food" and "fruit only" policies.[88]

The sensitivity studies reviewed above compared intakes of students under different policies with respect to bringing snacks to school or before and after an intervention. Significant differences were observed when intakes were measured at the group level compared to the individual level, thus these sensitivity studies were solely capturing group differences. Other studies have considered sensitivity in the development of tools, but did not test sensitivity.[99,100] Therefore, more studies are needed to not only assess validity evidence but also test sensitivity of dietary assessment tools for children.

1.d Summary

School children are not eating the recommended amount of fruit and vegetables, even though these foods are beneficial for their health.[2] Interventions such as nutrition education are developed to encourage school children to increase fruit and vegetable intake. Dietary assessment tools are needed to assess children's fruit and vegetable intakes and to decide whether the intervention is effective. Most of these tools, which include FFQs, brief screeners, 24-hour dietary recalls, and group-administered 1-day dietary recalls are used with adult participants and are adapted for use with children.[32] Thus, the evidence of validity for these tools is unknown. Each tool has its own advantages and disadvantages.

As FFQs are easy to administer, low cost, and measure usual diet, they can be used for epidemiology studies that assess trends or disease-diet links over a long period of time.[36] When FFQs are completed by children, a list of appropriate food and smaller portion sizes should be provided.[36] If there are only certain food groups that are of research interest, brief screeners may be chosen as they are shorter and have lower response burden. However, the evidence of validity for both measurements among children is from low to moderate or unknown. Thus, more validity studies should be done to understand the accuracy of both methods.

Stronger validity evidence was found in group-administered 1-day dietary recalls and 24-hour dietary recalls in the U.S. although they were only tested during school meals. When researchers have limited resources and need to assess dietary intake for one whole day, they can opt for group-administered 1-day dietary recalls. These tools share some advantages with FFQs and are shorter and less burdensome for children. Further, when fruit and vegetable intake is the only dietary outcome of interest, researchers may choose to use the DILQ. Lastly, with enough resources and training capacity, researchers can choose to use 24-hour dietary recalls to obtain detailed information about dietary intakes in children.

Although there is no perfect tool for every situation,[32] researchers can consider several factors such as resources, types of dietary outcomes (nutrients or behaviors), participants' characteristics, and research outcomes (short-term intake or usual intake).[101] University of Minnesota Extension evaluated its elementary student (3rd graders) nutrition program's effectiveness by measuring fruit and vegetable intake. They chose to use the DILQ and FVQ because they were inexpensive and easy to administer. The DILQ was chosen to assess one day fruit and vegetable intake; whereas the FVQ was chosen to assess usual fruit and vegetable intake. As described previously, the validity evidence for the DILQ has only been assessed for certain meals instead of a whole day[21,82,83], and the FVQ was never evaluated in young children.

Validation studies assess whether dietary instruments are measuring what they are meant to measure.[86] Although absolute validity may have fewer errors, relative or convergent validity is chosen more often as it only requires testing instruments with another previously-validated tool. Researchers use 24-hour dietary recalls, food records, and biomarkers as reference methods for testing tools. Factors that influence validity evidence are participants' BMI, time frame of the study, design of testing tools, and data management.[86]

Dietary measurement tools should also be sensitive enough to detect changes to evaluate effectiveness of interventions or different food policies implemented in schools.

Tools such as the DILQ and computerized 24-hour dietary recalls were sensitive enough to detect changes in fruit and vegetable intake among school children.[82,88] Sensitivity was not tested for other tools, thus more research is needed.

Validation studies are needed to evaluate validity evidence of FFQs, brief screeners, and group administered 24-hour dietary recalls among children. There are a variety of measures that can be chosen to evaluate validity evidence against untested dietary assessment methods in certain populations. Sensitivity needs to be considered when choosing a tool to assess effectiveness of interventions including nutrition education programs. More research is needed to better understand the factors that contribute to the validity evidence for measurement tools for young children.

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2. Purpose and Hypothesis

The purpose of this study was to determine the convergent or relative validity of the FVQ and DILQ in terms of fruit and vegetable intake, against 24-hour dietary recalls, with third grade students from a low income school and community center in the Minneapolis/St. Paul metropolitan area. The hypothesis is that fruit and vegetable intakes measured with the FVQ and DILQ will be in good agreement (deattenuated Pearson correlation coefficients ≥0.6) with intake measured with 24-hour dietary recalls.

3. Methods

Participants

Data were collected from 100 students attending one elementary school and 7 children participating in a summer community center program in the Minneapolis/St. Paul, MN metropolitan area during 2012-2013. Student participants were recruited from the Valley View Elementary School, Columbia Heights, MN. Enrollment in the school was approximately 488 students with 84% eligible for free or reduced price school meals[102] and 76% racially and ethnically diverse.[103]All students in three classes of 3rd grade students in 2012 and two of four classes in 2013 were asked to participate. Data were also collected from an additional 7 children participating in a summer day camp held at a community center in Minneapolis. Of the 82 summer camp participants, 88% were eligible for free or reduced price school meals (verbal communication, Community Center Director, summer 2013). The University of Minnesota Institutional Review Board, school principal, and community center director approved this study with informed consent obtained from parents and assent from participants.

Measures

The DILQ is a one-day food diary containing questions about daily activities (i.e., sports, leisure time) and eating occasions (i.e., breakfast, lunch, dinner, snacks) that occur throughout the day in chronological order. Questions about activities are included to enhance recall and to mask the intention of measuring fruit and vegetable (FV) intakes. Several questions were modified to suit the nomenclature of meal occasions in the U.S. (morning break became recess or break). Pictures from the original survey were also redesigned.

The FVQ includes two questions about usual FV intakes on most days. These two questions were modified to ask about intake on most days, where the original questions on the Food Behavior Checklist were based on usual intake for one day without accompanying illustrations.[104] The FVQ questions were modified to include measuring cup pictures that reflect MyPyramid serving sizes[105] such as ½ cup of whole strawberries, ½ cup of sliced apples, ½ cup of diced tomatoes, and ½ cup of green beans with response options of 0, 0.5, 1, 1.5, 2, 2.5 or 3 cups. A variety of fruits or vegetables were combined in the measuring cup pictures. For instance, ½ cup of strawberries and ½ cup of kiwi were in the picture illustrating 1 cup of fruit. The Food Behavior Checklist questions about FV were tested in adult women by comparing responses with serum carotenoid levels (correlations of 0.31 for fruit intake and 0.33 for vegetable intake).[68] The Food Behavior Checklist questions were modified and tested with children participating in the Expanded Food and Nutrition Education Program (8-9 years) for reliability (Cronbach α for a FV consumption factor = 0.67).[72] Construct validity for FV, milk, and healthful eating factors was acceptable based on a comparative fit index of 0.962 (<0.95 indicates excellent fit). Agreement with a reference method to measure FV intake was not tested.

In the current validation study, multiple, non-consecutive 24-hour recalls were used as the "gold standard" for comparison of FV intakes as assessed with the DILQ (1 day) and FVQ (2 or 3 days).[77]

Data collection procedures

On the morning of the first day, one researcher administered both the DILQ and FVQ in the classroom setting to the participants as a group. Each participant also completed a 24-hour dietary recall interview later in the day. On two additional days, within a month, two food record-assisted 24-hour recalls were conducted with the same participants. One day before the second and third 24-hour recalls, a researcher instructed participants to complete a food record in the classroom and reminded them to bring it back the next day. About one third (33%) of participants filled out and returned the food records for both recalls. Participants were not required to complete a food record prior to the first 24-hour recall because participants completed the DILQ and FVQ without records. Recalls were conducted to include two-weekday and one-weekend day recalls.

A standard protocol was developed for administration of the FVQ and DILQ by researchers. Researchers helped participants think about their usual intake when completing the FVQ by asking if participants usually had FV on most days. Furthermore, as the FVQ did not include FV juices, researchers instructed participants to include juice as part of their usual intake. When administering the DILQ, researchers prompted participants to write down more details about foods, such as "If you had a fast food meal (an example restaurant was indicated), what item did you actually eat? Write the names of the items."

Dietary recall interviews were conducted with each participant by trained researchers. Two of the three researchers were Registered Dietitians. One researcher certified in Nutrition Data System for Research (NDSR) software program use conducted a 9-hour training to familiarize the other two researchers with the interview procedures. Two of the three researchers practiced the interview procedures with 10 4th grade students (9 or 10 years old) from the same elementary school before study initiation.

In a first pass, researchers obtained a quick list of foods consumed, meal names, locations, and time of food consumption. Then, the list was reviewed to ensure no foods or beverages were omitted. In a second pass, more detailed information was collected, such as brand names, cooking methods, forms of foods, and serving sizes. Plastic bowls, plastic cups, measuring cups and spoons, and several food models were used to help students visualize portion sizes. For some foods, researchers asked children to draw the real sizes of food consumed. For the final pass, researchers reviewed all details with participants for verification purposes. All intakes were entered into the NDSR 2012 software program (Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN). Participants were given $10 gift cards as compensation for their participation.

Mixed foods or combination dishes can contain a substantial amount of vegetables,[106] therefore, they were included in vegetable categories when participants reported consumption in the DILQ. Two nutrition professors and two nutrition graduate students discussed and reached consensus as to which foods should be included in each category. For example, spaghetti and pizza were included in the vegetable group. French fries and baked products that contained fruits were excluded from the vegetable and fruit groups.

Comparison of fruit and vegetable intakes

The DILQ provided frequency of intake of food items. Therefore, to compare with intake based on 24 hour dietary recalls, frequencies were transformed into cup serving sizes using the NCI algorithm that was developed from the Eating at America's Table Study (EATS) according to NHANES 2003-2006 data. [44] For 24-hour dietary recalls, data output was in servings according to the Dietary Guidelines for Americans, 2005.[107] Therefore, servings from the NDSR reports were divided in half to convert to cups for comparison with DILQ and FVQ results.

Data from participants who had completed only 1 24-hour dietary recall and participants whose recalls were deemed to be unreliable based on researchers' judgment were excluded from the analysis. Results from participants who had completed 2 or 3 days of 24-hour dietary recalls were compared with FVQ results and results from the first 24 hour dietary recall were compared with DILQ results. Data were first examined with descriptive measurements for outliers. After review of NDSR results by two professors and one nutrition graduate student, data from participants with fruit or vegetable consumption <10 cups were included in data analysis. Some participants only had 1 day of 24-hour dietary recall data because they were absent during days when data were collected. Researchers discussed recall results for participants where intake seemed excessive or unusual (unreliable recalls) and came to a consensus about whether to include in the data analysis. These decisions were based on knowledge of typical intake by children over specific time periods.

Pearson correlation, deattenuated Pearson correlation and Bland-Altman analysis were used for comparisons to identify agreement between these measurements. Pearson correlation coefficients between 0.10 and 0.30 were considered weak relationships; between 0.30 and 0.50 were considered moderate; coefficients >0.5 were considered strong correlations.[48] The deattenuated Pearson correlation adjusted for the measurement error in the 24-hour dietary recall.[89] The deattenuated Pearson correlation analysis used the reliability of the 24-hour dietary recall, which was estimated with a linear mixed model.[108] For Bland-Altman analysis, bias and limit of agreement were calculated. Bias is the average of differences between two tools and limit of agreement is the variance of the bias. Two instruments are thought to be in agreement when bias is equal to zero and the variance of mean values is low or has a narrow limit of agreement.[92] Analysis was done using SAS software, Version 9.3 and 9.4 2012 SAS Institute Inc., Cary, NC, USA.

4. Results

One-hundred and seven participants were recruited. After excluding data from participants (n = 5) with only 1 24-hour dietary recall or recalls judged as unreliable, data from 102 participants were included in the analysis. Half of the students were male and the other half were female. Among these students, 41 (40%) students were Hispanic, 27 (26%) were Caucasian, 24 (24%) were African American, 3 (3%) were Asian, 2 (2%) were mixed race, and 5 (5%) reported Other as their racial/ethnic group.

Table 1 indicates the dietary intake of students based on 24-hour dietary recall data. On average, mean daily intake for students was 1737 kcal, 243 g carbohydrates, 66 g protein and 59 g total fat. Intake data for nutrients commonly found in FV are also included in table 1.

Table 2 illustrates mean FV intakes in cups comparing multiple 24-hour dietary recall results with FVQ results, and comparing 1st day 24-hour dietary recall results with DILQ results. Pearson correlation coefficients, deattenuated Pearson correlation coefficients, and bias were also included. Participants overestimated usual FV intake using the FVQ compared with 24-hour recall results (fruit: 1.93 vs. 1.05 cups and vegetable: 1.62 vs. 0.87 cups). Students also overestimated daily fruit intake using the DILQ (1.59 vs. 1.38 cups) but underestimated vegetable intake (0.55 vs. 0.90 cups). Less variability was observed in vegetable measurement using the DILQ (0.48) and multiple 24-hour dietary recalls (0.68). All agreements (Pearson correlation coefficients) between the measurements ranged from 0.11 to 0.23. However, agreement increased when deattenuation was applied. Deattenuated Pearson correlation coefficients ranged from 0.38 to 0.58.

The Bland-Altman analysis was conducted to acquire bias and limit of agreement between each tool. Students overestimated fruit intake by 0.24 cup and underestimated vegetable intake by 0.37 cup using the DILQ versus the first day 24-hour dietary recall. For the FVQ, students overestimated FV intake by 0.24 cup and 0.79 cup, respectively versus the multiple 24-hour dietary recalls. The widest limit of agreement or widest spread of differences between two instruments ranged from -3.00 cup to 3.40 cup when the DILQ was used to measure fruit intake. The widest spread of differences for other comparisons is also shown in Figures 1 to 4. Because the FVQ responses are categorical, the differences between continuous variables (24-hour dietary recall) and categorical variables (FVQ) tend to produce diagonal lines in Figure 1 and 2. In addition, because many students did not report consuming any vegetable item using the DILQ, and reported some vegetable intake via the 24-hour dietary recalls, the differences resulted in the diagonal line observed in Figure 3.

Table 1. Mean energy and nutrients intakes for 3rd grade participants via 24-hour dietary recalls (n = 102).

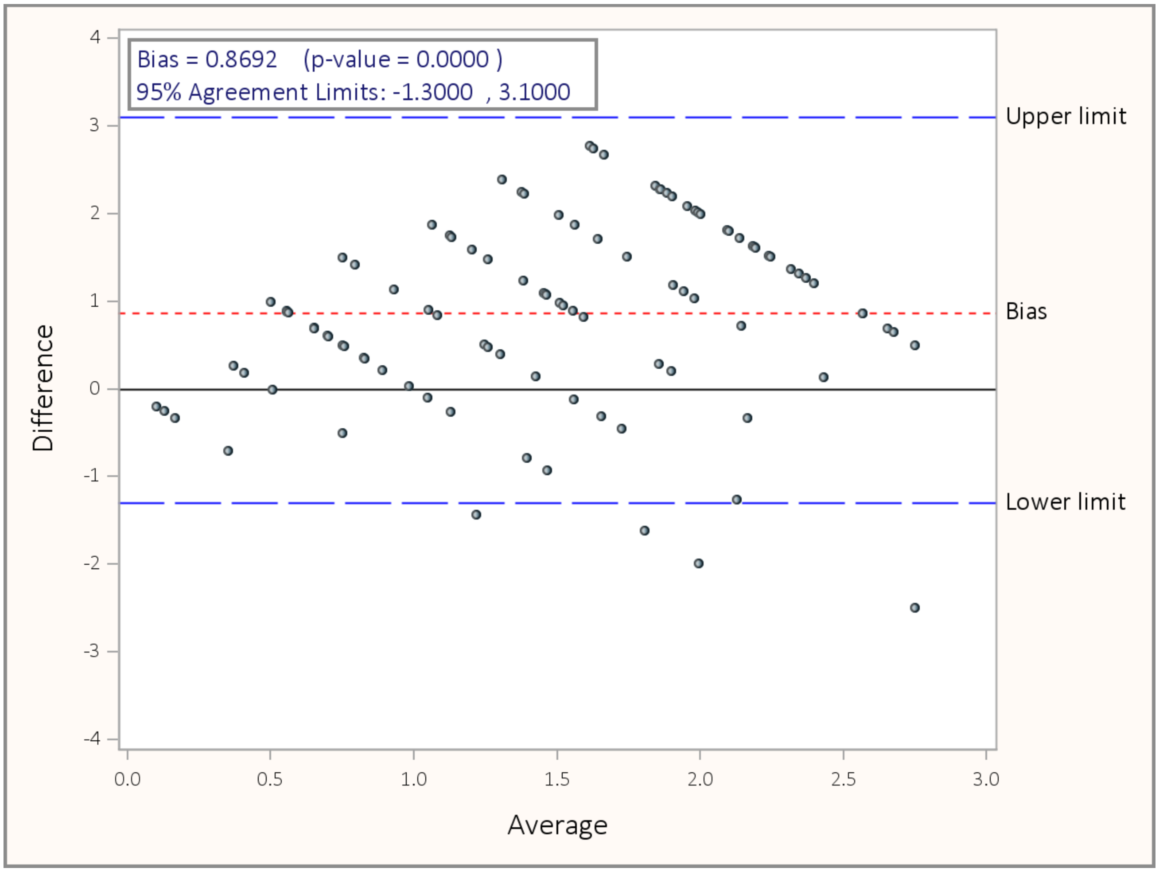
Energy and nutrients	Mean (±SD)
Energy (kcal)	1737±601
Carbohydrate (g)	243±84
Protein (g)	66±22
Total Fat (g)	59±28
Vitamin C (mcg)	91±56
Total Vitamin A Activity (IU)	5157±4759
Beta-Carotene equivalents (mcg)	2103±2749
Lycopene (mcg)	5731±6508
Total Folate (mcg)	39±177
Total Dietary Fiber (g)	15.3±6.9
Soluble Dietary Fiber (g)	4.5±1.8
Insoluble Dietary Fiber (g)	10.5±5.4
Potassium (mg)	2302±769

Table 2. Fruit and vegetable intakes (mean cups/day ±SD) and agreement between multiple 24-hour dietary recalls and the FVQ, 1st day 24-hr dietary recall and DILQ with Pearson correlation coefficients and bias (n = 100)

Food groups	Measures	n	Intakes (±SD)	p-value[b]	Pearson correlat-ion	Deattenuated correlation	Bias[c] (Limit of agreement[d])
Fruit	24-hr dietary recalls[a]	102	1.05 (0.76)	<.0001	0.23	0.54	0.87 (-1.30 - +3.10)
	FVQ	104	1.93 (0.92)				
	1st day 24-hr dietary recall	100	1.38 (1.29)	0.1435	0.16	0.38	0.24 (-3.00 - +3.40)
	DILQ	107	1.59 (1.15)				
Vegetable	24-hr dietary recalls	102	0.87[a] (0.68)	<.0001	0.17	0.58	0.79 (-1.20 - +2.80)
	FVQ	105	1.62 (0.84)				
	1ST day 24-hr dietary recall	100	0.90 (1.26)	0.0061	0.11	0.38	-0.37 (-3.00 - +2.20)
	DILQ	107	0.55 (0.48)				

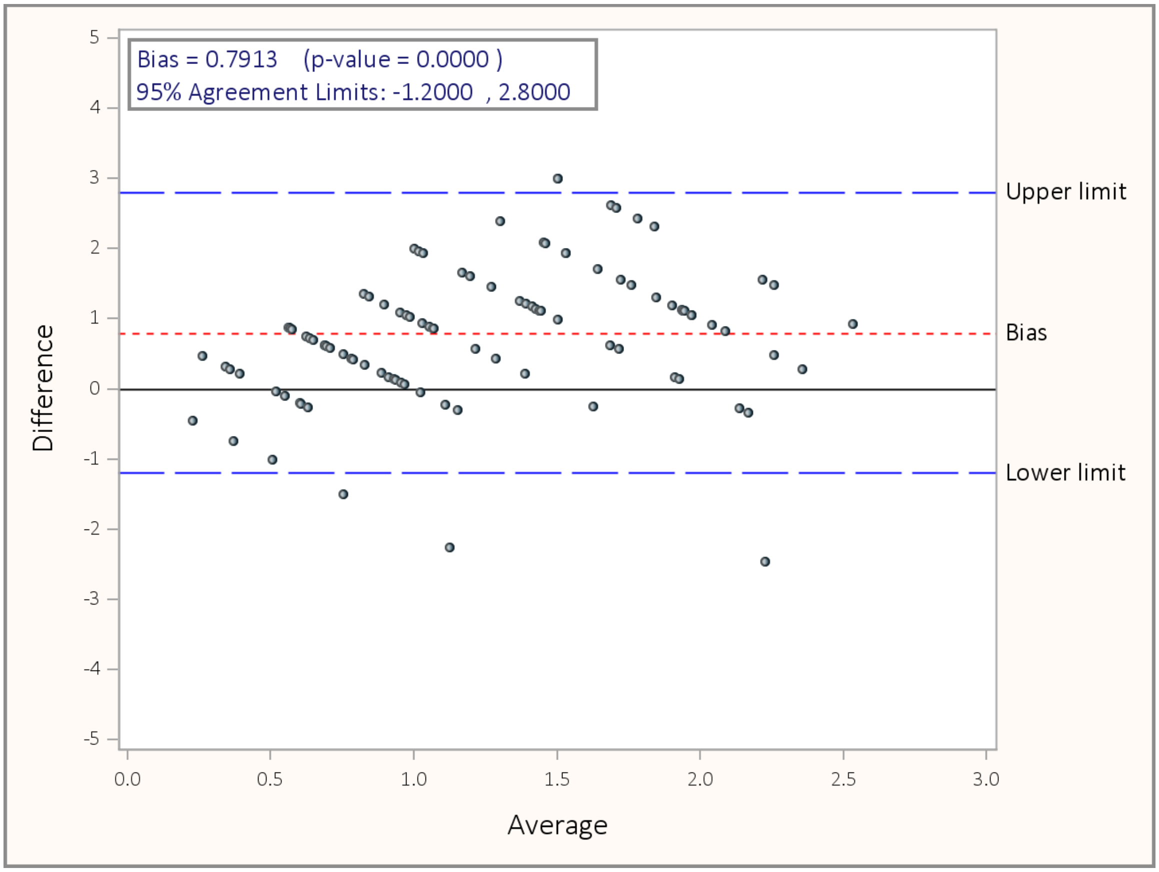
[a]Mean intakes of 2 or 3 days measured by 24-hour dietary recalls.
[b]p-value indicates the significance level of differences intakes between measures.
[c]Bias is the average of differences between measures (Difference = FVQ - 24 hour dietary recall or DILQ - 1st day 24-hour dietary recall).
[d]Limit of agreement = (Bias ±1.96 SD)

Figure 1. Agreement in fruit intake (Bland-Altman plots) assessed by the FVQ and multiple 24-hour dietary recalls (n = 100).[ab]



[a]The upper and lower line (dashed line) indicates limits of agreement within ± 2 SD. The middle solid line indicates 0 difference. The bias line (dotted line) is the average of the differences between the two instruments.
[b]Difference = FVQ – multiple 24-hour recalls. Average = ½ (FVQ + average of multiple 24-hour recalls)

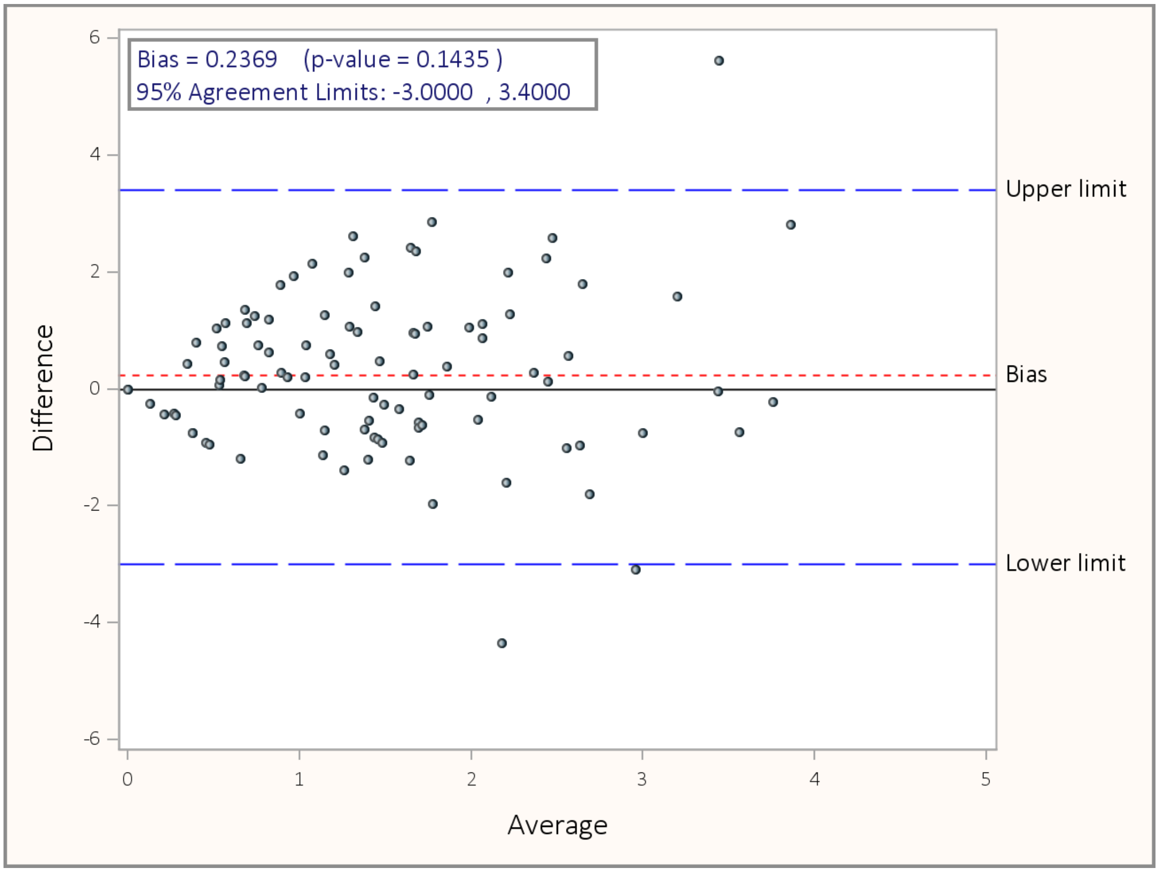
Figure 2. Agreement in vegetable intake (Bland-Altman plots) assessed by the FVQ and multiple 24-hour dietary recalls (n = 100).[ab]



[a]The upper and lower line (dashed line) indicates limits of agreement within ± 2 SD. The middle solid line indicates 0 difference. The bias line (dotted line) is the average of the differences between the two instruments.

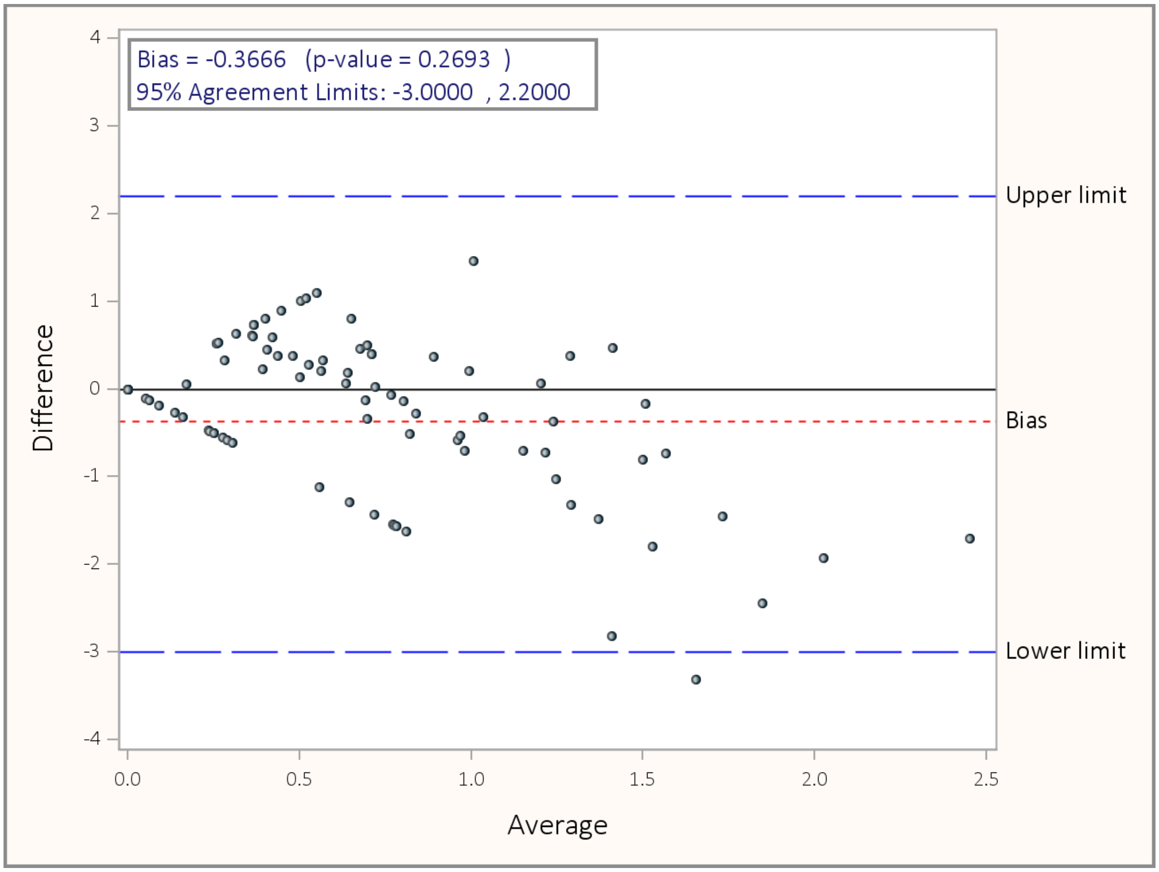
[b]Difference = FVQ – multiple 24-hour recalls. Average = ½ (FVQ + average of multiple 24-hour recalls

Figure 3. Agreement in fruit intake (Bland-Altman plots) assessed by the DILQ and 1st day 24-hour dietary recall (n = 99).[ab]



[a]The upper and lower line (dashed line) indicates limits of agreement within ±2 SD. The middle solid line indicates 0 difference. The bias line (dotted line) is the average of the differences between the two instruments.
[b]Difference = FVQ – multiple 24-hour recalls. Average = ½ (FVQ + average of multiple 24-hour recalls

Figure 4. Agreement in vegetable intake (Bland-Altman plots) assessed by the DILQ and 1st day 24-hour dietary recall (n = 99).[ab]



[a]The upper and lower line (dashed line) indicates limits of agreement within ± 2 SD. The middle solid line indicates 0 difference. The bias line (dotted line) is the average of the differences between the two instruments.
[b]Difference = FVQ – multiple 24-hour recalls. Average = ½ (FVQ + average of multiple 24-hour recalls

5. Discussion

Based on the weak correlation coefficients and lack of agreement indicated by the Bland-Altman analysis, the results of the current study suggest that neither the DILQ nor the FVQ performed well against 24-hour dietary recalls in assessment of FV intake by 3rd graders. Agreements based on Pearson correlations were low in all categories except for vegetable agreement for the 24-hour dietary recall versus the DILQ (r=0.35).[48] However, agreement increased when deattenuation was applied. The deattenuated correlation coefficient between the FVQ and repeated 24-hour dietary recalls for FV intake were 0.54 and 0.58 which indicates strong agreement. Yet, the low reliability of repeated measures in 24-hour dietary recalls for vegetable consumption resulted in an inflated deattenuated correlation coefficient, a limitation of calculating deattenuated Pearson correlation coefficients.[109] Although the deattenuated Pearson correlation coefficient was higher for the FVQ compared with the DILQ, especially for vegetables, neither instrument should be considered suitable for assessment of FV intake among 3rd graders.

Researchers have evaluated validity evidence for the DILQ among children from 7 to 11 years on a limited basis for assessment of FV intakes. The percentage match between combined FV intake measured by the DILQ and observation was 68.5% to 74% for two different elementary schools, respectively, and the kappa value ranged from 0.54 to 0.58, respectively.[82] Moore and colleagues provided evidence of validity for the DILQ by comparing FV intake results with 24-hour dietary recalls with children aged 9 to 11 years. Spearman's rank correlation for FV intake was 0.39 and 0.41, respectively, for the whole day excluding breakfast.[84] Wallen and colleagues compared the DILQ results for

FV intake against plate waste at school lunch. The kappa value for FV intake was 0.54 and 0.58, respectively. Wallen et al. modified the DILQ to include reports of portion sizes. They further compared DILQ portion size responses and plate waste measurements which resulted in a Spearman correlation coefficient of 0.57 for fruit intake.[83] They found a correlation of 0.32 for vegetable[83] intake which was similar to the results of the current study. All studies except Wallen et al. have higher correlations than what was observed in the current study.[83] This may be attributed to the fact that the comparison in the current study was for a whole day instead of just school lunch or a partial day. Furthermore, the previous validation studies only included whole FV; whereas mixed dishes that contained vegetables were included in the analysis for the current study. Agreement could have been affected by the transformation of frequency of intake from the DILQ using the algorithm to obtain portion sizes consumed. This may indicate that the DILQ should only be used to indicate the number of whole FV consumed and not to convert these data to portion sizes.

Other validation studies conducted among young children found low correlations between FFQs and reference tools. Domel and colleagues determined validity evidence for a 45-item FV FFQ among 4th and 5th grade children (9-11 years) that was developed based on the Willett FFQ.[110] Spearman's correlation coefficients observed between a food record and FV FFQ were from -0.04 to 0.21 in a month and -0.01 to 0.25 in a week.[111] Another 7-item FV FFQ's evidence of validity was evaluated among third grade students by comparing results to those obtained from food records.[63] The Pearson correlation coefficients for FV intakes were 0.139 and 0.157[63] similar to the findings in the current study. However, when a Block FFQ was compared against 3 24-hour dietary recalls among older children (10-17 years), no systematic differences were observed for vegetable consumption and good agreement was observed for fruit intakes when examined with Bland-Altman analysis.[62] The current study found systematic differences and a large variance in mean intakes between FVQ and 24-hour dietary recalls results which indicate that results from both tools do not agree well with each other. Agreement may differ between studies based on age of children and their ability to perform better when completing FFQs.

On average, participants reported consuming lower energy, lower amounts of carbohydrate and total fat and higher amounts of vitamin C, beta-carotene, lycopene, total fiber, and potassium compared with NHANES data 2009-2010.[112] Total energy intake was lower than the national average which is between 1863-2076 kcal.[112] This may indicate participants in this sample consumed more FV compared with the national sample. However, data from multiple 24-hour dietary recalls showed that students reported eating similar amounts of fruit (1.05 vs. 0.99 cups) but lower amounts of vegetables (0.86 vs. 0.98 cup) compared with NHANES 1999 to 2002.[2] The discrepancies between these studies may be caused by children's inability to recall dietary intake accurately or inability to estimate portion sizes correctly.[36]

Limitations

Although the results of the current study showed that the DILQ and the FVQ are not appropriate methods to evaluate FV consumption, these results are not generalizable beyond a low income, urban population of 8 to 9 year old children. The sample in the current study had a large number of Hispanic students (40%). The ability of the assessment tools to accurately assess FV intakes when used in a different setting with older children is unknown. Older children may have better memory skills and be able to better recall intake using the same tool. Furthermore, using self-report measurement tools (24-hour dietary recall) as the benchmark for other self-report measurement tools may not be the optimum method to evaluate validity. Although Lytle and colleagues have accumulated validity evidence for 24-hour dietary recalls among 3rd grade students in terms of nutrient intakes, students were not able to report accurate portion sizes.[77] This may affect the correlation coefficients between measurements. In addition, a value for the reliability of multiple 24-hour dietary recalls needs to be determined in order to calculate deattenuated Pearson correlation coefficients. In the current study, the same value for reliability was used to calculate deattenuated Pearson correlation coefficients between 24-hour dietary recalls and DILQ and FVQ results, even though the DILQ was only based on a 1-day diet record. This could be a limitation in the current study.

The DILQ and FVQ are not suitable assessment tools to evaluate FV consumption in the 3rd grade children from this sample. This finding is based on a small sample of low-income young children in an urban setting. More research is needed to identify strong evidence of validity for brief FV assessment instruments appropriate for use with young children.

6. Implications for Future Research and Application

Although the FVQ and DILQ are easy to administer to assess FV intakes, researchers or practitioners should be cautioned to limit use of the FVQ and DILQ to assess FV intakes of elementary students as young as 8 years. The DILQ may be useful under certain restrictions, such as estimating intakes of whole fruits, vegetables, and 100% fruit juices by tallying the number consumed.[82] The FVQ and DILQ need to be further tested with older children to determine convergent validity. Older children may have more mature cognitive skills to think in abstract terms and may better remember what they ate, thus yielding better agreement between FVQ, DILQ and 24-hour dietary recalls.

To assess typical FV intake, assessment tools that require parental assistance can be considered. For instance, the Child and Diet Evaluation (CADET) tool included a 24-hour tick list questionnaire which was used in England to assess dietary intake of children (3-7 years). Parents filled out the portion of questions when children ate with their parents. The findings suggested CADET has higher convergent validity (agreement with reference dietary instruments) than most FFQs.[47] Therefore, this tool can be used to assess dietary intake of elementary school children when administered in a group setting. A validation study should be conducted before implementation in the U.S. to ensure that CADET has validity evidence when used with children in the U.S.

Another possible child-friendly tool is the Internet-based Automated self-administered 24-hour dietary recall (ASA24) created by the NCI of the U.S.[113] Researchers tested the ASA 24 in children aged 8 to 13 and found students aged 8 had the lowest percentage of food matches at the food level (identifying the same foods in both ASA 24 and NDSR) and category level (identifying foods in the same category), and had the highest percentage of food omitted when compared with NDSR 24-hour dietary recalls.[114] However, the ASA 24 is still being tested and requires modification to enhance its readability and validity among younger children. This may be a good tool to assess FV intake given that students have Internet and computer resources at school.

Given the difficulty children have accurately recalling dietary intake, very few dietary assessment instruments with strong validity evidence exist for children, especially those 8 years of age or younger. Although information about preschooler's diets can be obtained by surrogates such as parents, surrogates may not always know what school-aged children eat or drink from school meals.[5] Instead, school food service personnel or teachers who are with children during school lunch may act as surrogates and observe children's dietary intake. More research is needed to incorporate observational data from teachers and school food service personnel.

Future studies should focus on several additional areas. A representative sample from the state of Minnesota or the U.S. should be included in a validation study in order to make the results generalizable. The FVQ and DILQ should be tested with older children to determine their evidence of validity. Unfortunately, assessing evidence of validity using self-report instruments against other self-report instruments may not be ideal. Using observation as a standard to test these tools may be a better option.

7. Conclusion

In conclusion, the FVQ and DILQ are not suitable to assess young children's FV intake. Other tools should be considered to evaluate FV intake and more research is needed to determine convergent validity of these instruments.

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9. Appendix

Measures

Day in the Life Questionnaire (pp.74)

Fruit and Vegetable Questionnaire (pp.75)

A DAY IN THE LIFE OF. . .

What did you do? **YESTERDAY MORNING**

8 Did you have something to eat and drink for breakfast? (What did you have?)

____

____

______________ drink ______________

My Breakfast

Draw your breakfast here.

9 Did you watch television yesterday morning?

YES	NO

10 Did you have anything else to eat or drink between breakfast and before starting school? (What did you have?)

____

____

____

11 How did you travel to school in the morning?

			
Walk	Cycle	By Bus	By Car

Page 7

1. How many cups of fruit do you eat on most days? (Circle one.)

NONE

½ CUP

1 CUP

1½ CUPS

2 CUPS

2½ CUPS

3 CUPS

2. How many cups of vegetables do you eat on most days? (Circle one.)